

INSTRUCTION MANUAL

MODEL API-1-3D
SPHERICAL-COORDINATE-
INTEGRATOR
CONVERTER UNIT

SCIENTIFIC-ATLANTA, INC.





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MODEL NO. 2621
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INSTRUCTION MANUAL

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SECTION 1

GENERAL DESCRIPTION

1.1 Introduction

The Scientific-Atlanta Model API-1-3D Spherical-Coordinate-Integrator Converter Unit is designed for use in computing the directivity of antennas. The converter unit functions in conjunction with a Scientific-Atlanta Model API-1B Antenna-Pattern Integrator to perform the desired integration. By accomplishing several calculations automatically, the converter unit greatly simplifies the process of antenna-pattern integration. A single calculation is now sufficient to determine antenna directivity when specified elevation increments are used.

For compactness and increased reliability, all circuitry of the converter unit consists of solid-state components.

1.2 Specifications

Additional Equipment Required for Spherical-Coordinate Integration	Scientific-Atlanta Model API-1B Antenna-Pattern Integrator
θ -Information Signal Input	Stator leads of 115-volt, 60-cps synchro transmitter geared 1:1 with monitored motion
Integrating Modes	2° increments, 5° increments, auxiliary
Conformity of Sin θ Weighting Factor	$\pm 0.5\%$
Dimensions	3-1/2 inches high by 19 inches wide by 16 inches deep
Power Requirement	75 watts at 115 $\pm$ 5 volts rms, 60 cps
Weight	15 pounds net; 20 pounds shipping

1.3 Principles of Operation

The Scientific-Atlanta Model API-1-D3 Spherical-Coordinate-Integrator Converter Unit converts the Model API-1B Antenna-Pattern Integrator for use in weighted

spherical-coordinate integration by accomplishing three functions:

- (1) Each solid angle of the sphere of integration is equally weighted automatically.
- (2) Constants used in calculating the directivity of an antenna are automatically taken into account (except for the auxiliary mode).
- (3) Additional count storage is provided.

When the directivity of an antenna is measured through the use of the Model API-1B Antenna-Pattern Integrator alone (see the instruction manual for the Model API-1B), ϕ cuts are taken at various θ angles, and the data for each cut are recorded individually. At the end of the integration process, the results for each ϕ cut must be weighted individually by multiplying the result by the sine of the θ angle at which the particular ϕ cut was made.

In weighted spherical-coordinate integration, the converter unit supplies the counting clock frequency, which varies as the sine of θ , thereby weighting automatically. Some of the constants which appear in the equations used when calculating directivity with the Model API-1B Antenna-Pattern Integrator are automatically eliminated from the calculations when the converter unit is used; this is accomplished by making the calibration clock frequency and the maximum integrating frequency differ by a selected amount. The remaining constants are removed by proper selection of the countdown ratio of the converter-unit counters. It should be noted, however, that for θ increments other than 2° or 5° the computation of directivity involves only minor additional calculations.

Since the Model API-1B has sufficient count storage for only one pattern cut, additional counters are provided in the converter unit to allow complete sampling over the entire sphere of integration.

For certain antennas the power in one polarization is virtually zero and may be neglected without appreciable error. Using the preselected elevation increment (2° or 5°), the directivity of this type of test antenna is found simply by taking the reciprocal of the number displayed by the Model API-1B INTEGRATOR READ-OUT. For this purpose, the number displayed on the API-1B is considered to be preceded by a decimal point.

SECTION 2 INSTALLATION

2.1 Power

Connect the power cord to a 115-volt, 60-cps outlet.

2.2 API-1B Cable

Connect the cable from the API-1B chassis to J1.

2.3 θ -Axis Drive

Connect the cable from the θ -axis 1:1 synchro to J2.

SECTION 3

OPERATION

3.1 Calibration

Apply power to the converter unit and allow five minutes for stabilization of the equipment. Define the two orthogonal polarizations of the test antenna for which radiation measurements will be made. The 2D-3D switch on the Model API-1B should be set to the 3D position, and the API-1B 100 kc crystal should be removed for all phases of weighted, spherical-coordinate integration.

Set the INTEGRATE-CALIBRATE switch of the converter unit to the CALIBRATE position, and then follow the calibration instructions given in the Model API-1B instruction manual. In the calibration procedure one must search through the sphere of integration using each of the previously defined polarizations in turn to determine the direction and polarization for which the input signal is a maximum. After calibration has been completed, system gains must not be changed for the duration of the integration process.

3.2 Operation

First accomplish the calibration as outlined in paragraph 2.1 of the API-1B instruction manual. Then proceed as described below.

3.2.1 Automatic Operation

The Spherical-Coordinate Integrator Converter unit is designed for use with a Scientific-Atlanta Positioner Programmer, in which case all operations are automatic.

To operate the API-1B and the converter unit automatically, perform the following procedure:

- a. Place the INTEGRATE-CALIBRATE switches of the Model API-1B and the converter unit in the INTEGRATE position.

- b. Set the SAMPLE GENERATOR DRIVE switch of the Model API-1B to the desired position.

c. Set the MODE switch of the converter unit to the desired θ increment (the same as preset on the positioner programmer).

d. Place the MANUAL-AUTOMATIC switch of the Model API-1B in the AUTOMATIC position.

e. Position the test antenna at its initial condition, $\theta = 0^\circ$ and $\phi = 0^\circ$. Choose one of the two previously defined orthogonal polarizations for the antenna.

f. Depress the RESET button on the API-1B. This resets all counters to zero.

g. Begin the integration process by programming the test antenna to cover the sphere of integration.

h. After the complete sphere of integration has been covered, stop the positioner programmer and record the number displayed on the API-1B INTEGRATOR READOUT as C_{F1} .

i. Repeat steps (e) through (h) for the orthogonal polarization to obtain a number C_{F2} .

j. Obtain a number, $r_1(\theta, \phi)$, proportional to the radiation intensity for one polarization in the direction of interest. This number is obtained by dividing the recorder chart reading for the direction (θ, ϕ) by the full-scale chart reading. An alternative method for obtaining r_1 consists of returning the API-1B and API-1-3D units to the calibrate position after positioning the antenna in the direction of interest with one selected polarization. For this situation r_1 is equal to the number displayed on the API-1B divided by 1000.

k. Repeat step (j) for the orthogonal polarization to obtain a number, $r_2(\theta, \phi)$.

l. Use the results of steps (h) through (k) to solve the following equation for directivity in the direction of interest.

$$d(\theta, \phi) = \frac{r_1(\theta, \phi) + r_2(\theta, \phi) \times 10^4}{C_{F1} + C_{F2}}$$

3.2.2 Manual Operation

- a. Perform steps (a) and (b) of the procedure for automatic operation.
- b. Set the MODE switch of the converter unit for the desired θ spacing. (AUXILIARY is used for all spacings other than 2° or 5° .)
- c. Set the MANUAL-AUTOMATIC switch on the API-1B chassis to MANUAL.
- d. Position the test antenna to $\theta=0$ preparatory to making ϕ pattern cuts.
- e. Reset all counters to zero by depressing the RESET button on the API-1B.
- f. Make a series of ϕ cuts at the selected θ spacing until the entire sphere of integration is covered.
- g. After each ϕ cut, stop the positioner, reposition it in θ , and depress the MANUAL RESET button on the converter unit. This provides the contact closure which resets the sample counter and the associated sampling circuitry of the API-1B prior to another cut.
- h. Record the final number displayed on the API-1B INTEGRATOR READOUT as C_{F1} .
- i. For 2° or 5° θ spacing, determine the directivity as in steps (i) through (1) of the procedure for automatic operation. For all other spacings, use the equation below to calculate the directivity of the test antenna in the plane of polarization under study:

$$d(\theta, \phi) = \frac{63.7M \quad r_1(\theta, \phi) + r_2(\theta, \phi)}{C_{F1} + C_{F2}}$$

where M is the number obtained by dividing 180° by the integrating-mode increment used.

3.2.3 Sectional Integration

If it should be desirable to perform the integration by sections rather than in a single complete process, perform the following steps:

- a. Integrate over a solid-angle section and record the number displayed on the API-1B INTEGRATOR READOUT. Reorient the antenna at the start of the next section and depress the RESET button on the API-1B.

- b. Repeat step (a) for all remaining sections, ensuring that the sections do not overlap. This is very important, since if a pattern cut contained in any section is taken at the same angle, with respect to the coordinate system of the test antenna, as a cut in any other section, an error will be introduced.

- c. Total the readings taken for all sections to obtain a number which will be the same as one resulting from a single, complete coverage of the sphere of integration. This resulting number can then be used to compute the directivity in the same manner as if the number had been obtained by a single, complete integration.

- d. The orientation of the test antenna with respect to the positioner may be changed between section integrations so long as no overlapping of sections results from such changes and all sections are covered.

3.2.4 Directivity Multiplier

If prior knowledge of an antenna indicates that its directivity will be greater than ten, the DIRECTIVITY MULTIPLIER switch should be set to the X10 position. Compute directivity in the normal manner as described in sections 3.2.1 through 3.2.3. Multiply the resulting value of directivity by ten to obtain the actual directivity of the antenna.

For all antennas that are known to have a directivity less than ten, the DIRECTIVITY MULTIPLIER switch should be set to the X1 position.

SECTION 4

DETAILED DESCRIPTION

4.1 Introduction

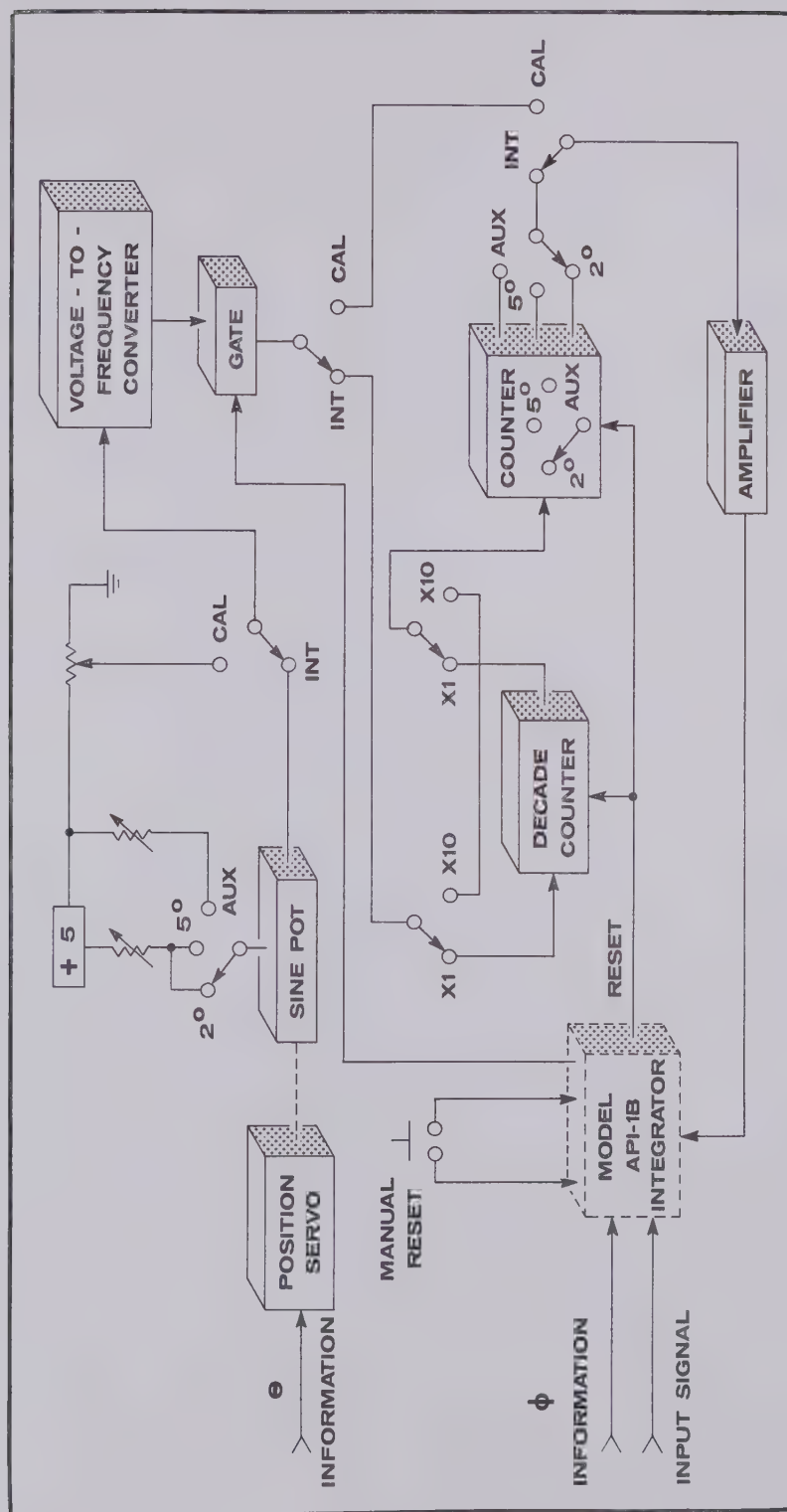
Read the instruction manual for the Scientific-Atlanta Model API-1B Antenna-Pattern Integrator before attempting to understand the operation of the converter unit. A better understanding of the interchange of signals between the two units can thus be obtained.

The sequence of events which occur in the integration operation is as follows (see Figure 4.1): θ information is received by a position servo from a synchro which is geared 1:1 to the monitored motion of the test antenna. The servo system positions a sine potentiometer at a shaft angle which has a 1:1 relationship to the θ angle of the test antenna. Reference voltages are applied to the sine potentiometer, and an output is taken from it. Orientation with the shaft is such that maximum output is obtained from the potentiometer when the test-antenna θ angle is 90° , and zero output is obtained when θ is either 0° or 180° .

The output of the potentiometer is applied to a voltage-to-frequency converter whose output frequency is proportional to the sine of the θ angle of the test antenna. The signal from the voltage-to-frequency converter is then counted-down, amplified and fed to the API-1B integrator, in which it assumes the function of the oscillator clock. This results in an automatic weighting of the integration count by a factor proportional to the sine of angle θ .

The reference voltages applied to the sine potentiometer are switched according to whether the converter unit is operating in the 2° , 5° , or auxiliary mode. This causes the voltage-to-frequency converter to develop a different maximum frequency for each case. The maximum frequencies are as follows:

MODE	FREQUENCY (kc)
Calibration	100
Integrate 2°	$87.2 \sin \theta$
Integrate 5°	$87.2 \sin \theta$
Integrate Auxiliary	$100 \sin \theta$



The variable-frequency signal is gated in the converter unit by a signal from the API-1B integrator. Next, the pulses of the gated signal are counted and stored. The storage capacity of the converter-unit counters is changed according to the mode of operation. The output pulses of the final counter are then amplified and fed to the API-1B integrator, where they are counted and stored in a bank of decade counters. A visual display on the panel of the API-1B is provided for the contents of the four most significant decade counters.

The combination of variable-count storage and variable maximum frequency in the converter unit eliminates the constants in the calculation of antenna directivity in the 2° and 5° modes of operation. The output frequency during calibration is constant at 100 kc, and the storage of the converter unit is not used.

4.2 Position-Servo System

The position servo of the converter unit is driven by the error signal derived from a synchro transmitter which is geared to the θ axis of the positioner. Figure 4.2 includes the schematic of the position servo.

The stator windings of a synchro transmitter (geared 1:1 to the positioner θ axis) are connected to the stator windings of a synchro control transformer, 2B1, in the converter unit. The driving signal for the servo amplifier is taken from the rotor of the control transformer (CT). An error signal appears at the rotor of the transformer when the CT and the synchro transmitter are not in coincidence. This signal is amplified and applied to the control winding of the servomotor, 2B2, which drives the rotor of the control transformer to coincidence with the synchro transmitter. The sine potentiometer, 2R10, is geared to the control transformer in such a way that when the system has been nulled, the shaft position of the potentiometer will correspond with the θ position of the test antenna.

The twin-T network, consisting of resistors 2R4 through 2R9 and capacitors 2C1 through 2C4, is an ac equalizing network which increases the stability of the servo loop.

The error signal from the equalizing network is applied to the base of transistor

3A3Q1. Transistors 3A3Q1 and 3A3Q2 constitute a feedback pair which amplify the error signal; the ac feedback (hence, the gain of the amplifier) is adjusted by varying potentiometer 3R1. The output of the feedback pair is applied to the base of 3A3Q3 through an RC low-pass filter (3A3R6, 3A3R7, and 3A3C3) which removes extraneous signals.

Transistors 3A3Q3 and 3A3Q4 form an ac-difference-amplifier driver stage. The output of this stage is transformer coupled to a class B push-pull output stage, consisting of transistors 3Q1 and 3Q2, which feeds the control winding of 2B2, a 5-watt servomotor. Diode 3CR1, mounted so that it assumes the same temperature as 3Q1 and 3Q2, provides temperature compensation for the output stage by varying the dc bias applied to the bases of these transistors as a function of temperature.

4.3 Voltage-to-Frequency Converter

The voltage-to-frequency converter is a Vidar Corporation product. The repetition rate of its output pulse train varies linearly between 0 and 100 kc for input voltages between 0 and 10 volts. The shaft angle of sine potentiometer 2R10 varies directly with the θ angle of the test antenna, providing an output which is proportional to the sine function of the θ angle; thus, the output of the voltage-to-frequency converter varies as the sine of the θ angle. As INTEGRATION MODE switch S2 is moved from one setting to another, various dc reference voltages are applied through switch S2-A, thereby varying the maximum repetition rate of the voltage-to-frequency converter.

The output of the voltage-to-frequency converter is amplified and gated by transistor 3A4Q2, then applied through switches S3-B and S5-A to the input of the first counter (the junction of 3A2C2 and 3A2C5). The gating signal is received from the API-1B through pin G of connector J1 and is shaped by transistor 3A4Q1. The output of the variable reset counter is fed through switches S2-C and S3-C and is used to trigger the monostable multivibrator consisting of 3A4Q3 and 3A4Q4. The output of this multivibrator is applied to the line driver consisting of 3A4Q5, 3A4Q6, and 3A4Q7, the output of which is coupled through 3A4CR9, 3A4C7 and 3A4R14 to the API-1B. In the CALIBRATE mode the two counters (3A1 and 3A2) are bypassed and the gated signal is fed from the collector of 3A4Q2 through switches S3-B and S3-C to the input of the monostable multivibrator.

4.4 Weighted Spherical-Integration Mode of the API-1B

In the non-weighted mode of operation, V6-3 of the API-1B (see Figure 6 in the API-1B instruction manual) acts as a combination oscillator and gate.

In weighted operation with the converter unit, V6-3 functions as an amplifier, and the 100-kc crystal in the API-1B must be removed. With switch S1-3 in the 3D position, the screen grid of V6-3 is grounded; this prevents V6-3 from being gated off and on by the counter-gate bistable multivibrator.

4.5 Counters (See Figures 4.3 and 4.4)

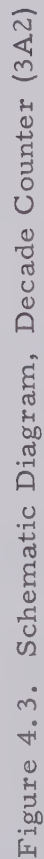
In the INTEGRATE mode the output of transistor 3A4Q2 is applied through switches S3-B and S5-A to pin A of the decade counter, 3A2. The output of counter 3A2 is applied through switch S5-B to pin E of the variable reset counter, 3A1. In combination, the two counters provide a total countdown of 20:1 (for 5°), 50:1 (for 2°), or 100:1 (for auxiliary).

The variable reset counter has a different type of countdown for each mode of operation. These are: 2:1 (for 5°), 5:1 (for 2°), and 10:1 (for auxiliary).

The 5:1 countdown is accomplished as follows: A three-stage binary counter, consisting of transistors 3A1Q1 through 3A1Q5, and 3A1Q7, is allowed to reach a count of four. At the count of four the collector of 3A1Q2 goes from a negative level to ground. This positive excursion is differentiated and applied to the base of 3A1Q3, causing 3A1Q3 to be cut off. The counter will have received four pulses but will occupy a state corresponding to a binary count of five. A diode AND gate is used to detect the "five" state. The output of the AND gate is applied through resistor R41 to the base of 3A1Q5, causing 3A1Q5 to conduct and 3A1Q7 to be cut off. The counter then occupies a state corresponding to a binary count of seven (111). Upon receiving the fifth pulse, the counter acts in a normal manner and returns to the "zero" state. For the 2° mode of integration, the output of the variable reset counter is taken from pin H.

The 10:1 countdown is accomplished in a manner similar to the 5:1 countdown. An additional binary stage is simply used to give a 2:1 countdown of the 5:1 output of the previously mentioned three-stage counter. For the AUXILIARY mode of

NOTE
1. ALL RESISTORS IN COYS. 10% & 1/2 WATT
FILLED IN COYS. SPECIFIED.
2. ALL COYS. IN COY. COY. UNLESS
OTHERWISE SPECIFIED.





integration, the output of the variable reset counter is taken from pin K.

The 2:1 countdown is accomplished by inhibiting the feedback to the first stage of the counter and taking an output from the first stage. For the 5° mode of integration, the output of the variable reset counter is taken from pin L.

For the 10:1 countdown of the decade counter, a four-stage binary counter, consisting of transistors 3A2Q1 through 3A2Q8, is allowed to reach a count of nine. A diode AND gate detects this state and gives an output which is used to set the second and third bistable stages, in which transistors 3A2Q5 and 3A2Q2 are conducting and Q7 and Q4 are cut off. At this time the four-stage binary counter is in a state which would normally correspond to a count of fifteen (1111). Upon receiving the tenth input pulse, the counter acts in a normal manner and returns to the "zero" state.

4.6 Contact Closure

A contact closure, required by the API-1B after each ϕ -pattern cut in manual operation, occurs when MANUAL RESET button S4 is depressed. In automatic operation this closure is unnecessary because the normal 1000-count shutoff signal from the sample counter to the integrator-shutoff bistable multivibrator is interrupted by MANUAL-AUTOMATIC switch S2-4, and the integrator is free to sample whenever the test antenna is moving over the sphere of integration.

4.7 Directivity Multiplier Switch

The DIRECTIVITY MULTIPLIER switch is used when it is desired to increase the accuracy of directivity computations for antennas whose directivity exceeds a value of ten. It simply allows the decade counter, 3A2, to be bypassed when switch S5 is in the X10 position.

SECTION 5

ADJUSTMENTS AND MAINTENANCE

5.1 Static Voltage Measurements

Unless otherwise specified, all dc measurements listed in Table 5.1 were made with a 20,000-ohms-per-volt dc voltmeter between chassis ground and the point indicated; line voltage was maintained at 115 volts rms.

For the duration of the measurements, conditions of the system were as follows:

- a. Test antenna set at $\theta = 90^\circ$, with antenna immobile.
- b. Antenna signal input disconnected from the API-1B, and 20- to 100-volt dc calibration voltage applied instead.
- c. Calibration procedure accomplished as given in paragraph 2.1 of this manual.
- d. All controls in CALIBRATE position.
- e. Converter-unit MODE switch in AUX^{*} position.
- f. System cleared by momentarily depressing the RESET button on the panel of the API-1B.

If trouble develops in the voltage-to-frequency converter, refer to the Vidar instruction manual for troubleshooting procedures.

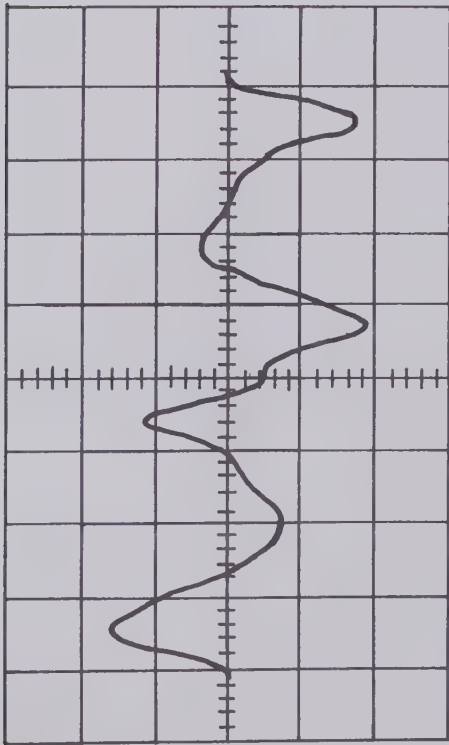
5.2 Waveforms

The waveforms shown in Figure 5.2 were obtained on a Tektronix Model 515A Oscilloscope with the controls set as follows:

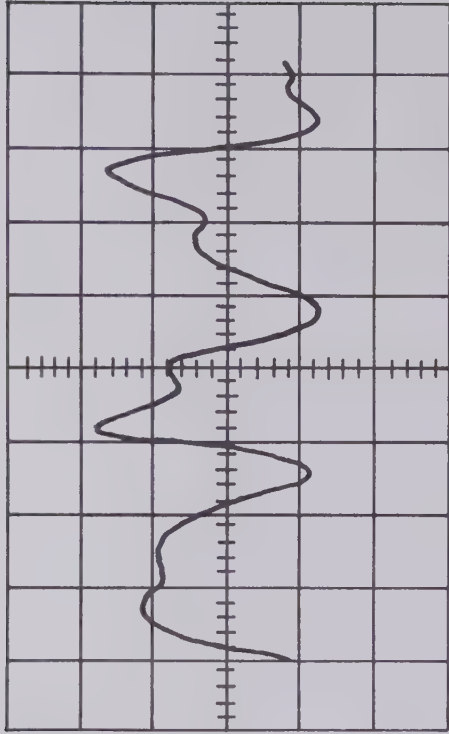
TRIGGER SLOPE	EXT +
TRIGGER MODE	AC SLOW
TIME/CM	UNCALIBRATED (1.66 msec/cm; see text below)

TABLE 5.1
STATIC VOLTAGES
(dc unless indicated otherwise)

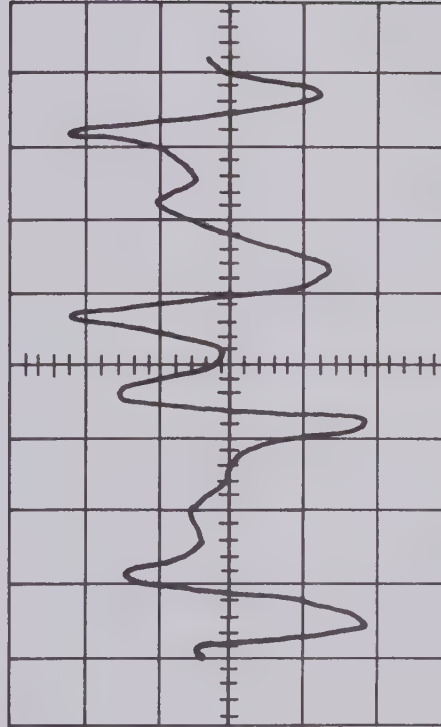
<u>Transistor</u>	<u>Base</u>	<u>Emitter</u>	<u>Collector</u>
3Q1	+10.5	+10.5	-15.0
3Q2	+10.5	+10.5	-15.0
3Q3	-17.0	-17.0	-30.0
3A1Q1	+2.3	0	-13.0
3A1Q2	+0.3	0	-13.0
3A1Q3	-0.3	0	-0.1
3A1Q4	-0.3	0	-0.1
3A1Q5	+0.3	0	-13.0
3A1Q6	+2.3	0	-13.0
3A1Q7	-0.3	0	-0.1
3A1Q8	-0.3	0	-0.1
3A2Q1	+2.3	0	-13.0
3A2Q2	+0.3	0	-13.0
3A2Q3	-0.3	0	-0.1
3A2Q4	-0.3	0	-0.1
3A2Q5	+0.3	0	-13.0
3A2Q6	+2.3	0	-13.0
3A2Q7	-0.3	0	-0.1
3A2Q8	-0.3	0	-0.1
3A3Q1	+3.8	+4.0	-2.9
3A3Q2	-2.9	-1.0	+4.9
3A3Q3	+5.0	+5.2	-16.0
3A3Q4	+5.0	+4.0	-16.0
3A4Q1	+6.0	0	-0.5
3A4Q2	-0.3	0	-2.0
3A4Q3	+1.8	0	-16.0
3A4Q4	-0.2	0	-0.4
3A4Q5	+7.2	+6.0	-16.0
3A4Q6	-16.0	-16.0	-17.0
3A4Q7	-16.0	-16.0	+5.0
3A4Q8	-17.0	-17.0	-30.0
3A4Q9	-6.8	-6.8	-17.0
	<u>Diode</u>	<u>Anode</u>	<u>Cathode</u>
	3A3CR2	-7	
	3A3CR3	-1	
	3A3CR4	-5	
	3CR1		+10.7



TERMINAL R1 TO TERMINAL R2
OF 2B1 0.1 VOLT PER DIVISION



3 Q1 COLLECTOR
5 VOLT PER DIVISION



3A3Q1 BASE
10 MILLIVOLTS PER DIVISION

Figure 5.2. Waveforms

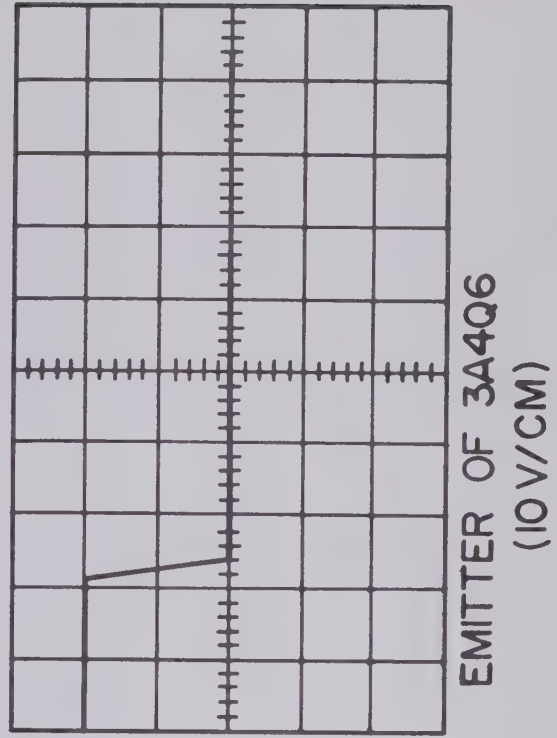
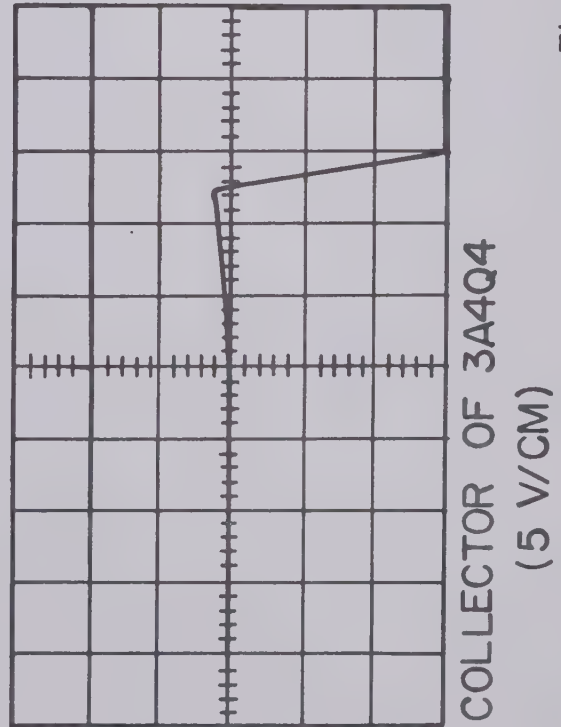
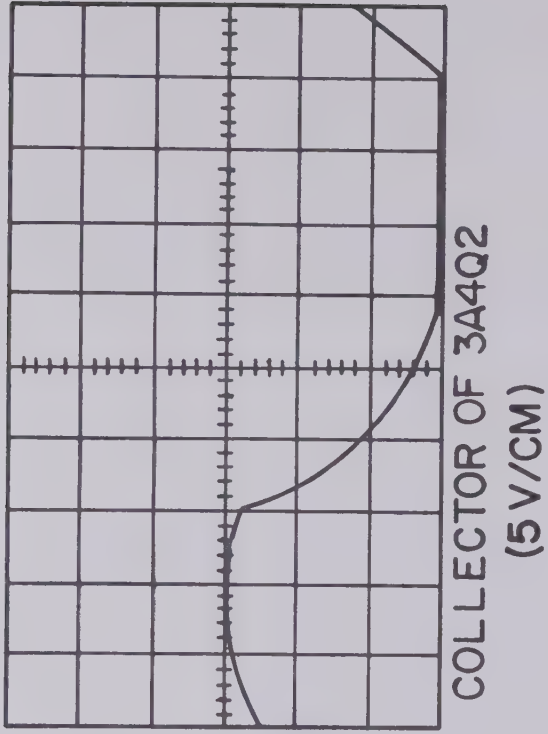
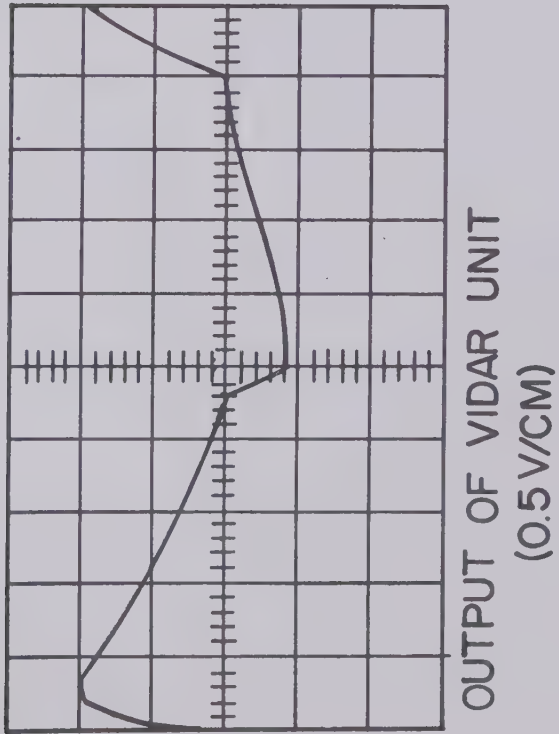


Figure 5. 3
Waveforms

VOLTS/CM	As required
INPUT SELECTOR	AC

The EXTERNAL TRIGGER jack of the oscilloscope was connected to the ac line at the junction of F1 and DS1, the ground lead was connected to the chassis of the converter unit, and the sweep controls were adjusted such that the positive half of the 60-cycle line voltage appeared at the left side of the graticule and one cycle filled the graticule horizontally.

The ground lead of the oscilloscope was connected to the converter chassis for all measurements unless otherwise noted.

The waveforms shown in Figure 5.3 were obtained in a similar manner, but with the controls of the oscilloscope set as follows:

TRIGGER SLOPE	INT +
TRIGGER MODE	AC FAST
TIME/CM	1 μ sec/cm
VOLTS/CM	As required
INPUT SELECTOR	AC

The ground lead of the oscilloscope was connected to the chassis of the converter unit.

5.3 Adjustments

All service adjustments are set at the factory and will not require attention except where normal aging of components or malfunctions occur.

5.3.1 Volts Adjust

Adjust 3R2 to obtain -17 volts dc from the emitter of 3Q3 to the chassis.

5.3.2 Notch Frequency and Notch Depth

Set the synchronization controls of an oscilloscope to LINE +. With the servo

system nulled, observe the waveforms on the hot ac line and the collector of 3Q1 in the push-pull stage. Use chassis ground for reference.

Manually displace the shaft of the servomotor a small amount to introduce a position error. Adjust potentiometers 2R4 and 2R5 to obtain a phase shift of 90° between the signal on the hot ac line and the signal on the collector of 3Q1. Release the shaft of the servomotor and observe the return to null. If the system overshoots excessively, adjust 2R5 to minimize the overshoot, meanwhile readjusting 2R4 to maintain a phase shift of 90° between the signal on the hot ac line and the signal on the collector of 3Q1.

5.3.3 Gain

Adjust 3R1 for the maximum gain (clockwise rotation) which produces no instability as evidenced by a jittering gear system or a loud buzz at null. Reduce the gain setting to the point at which the gear system stops jittering and the buzzing ceases.

5.3.4 Maximum Frequency Output

Disconnect the cable from the θ -information input, J2. Rotate the shaft of the sine potentiometer to obtain maximum positive voltage between the slider of the sine potentiometer and chassis ground. Use a pulse counter to monitor the signal between the output of the voltage-to-frequency converter and chassis ground.

Set the INTEGRATE-CALIBRATE switch to CALIBRATE. Adjust 2R1 until the repetition rate of the monitored signal is 100 kc.

Set the INTEGRATE-CALIBRATE switch to INTEGRATE and the MODE switch to AUX. Adjust 2R3 until the repetition rate of the monitored signal is 100 kc.

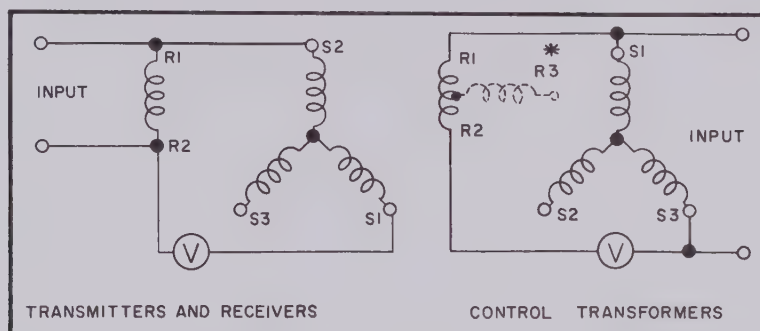
Set the INTEGRATE-CALIBRATE switch to INTEGRATE, and set the MODE switch to 5° . Adjust 2R2 until the repetition rate of the monitored signal is 87.2 kc.

SYNCHRO ELECTRICAL ZERO

The electrical zero of a synchro is defined as that position of the rotor, with respect to the stator, where the voltage between S1 and S3 is zero and where the voltage from S2 to S1 is in phase with the voltage from R1 to R2.

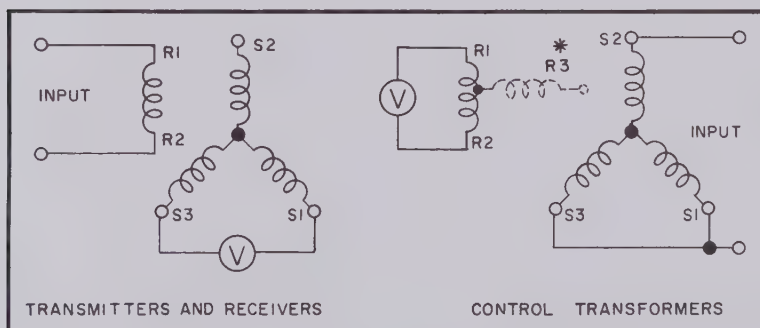
There are two null positions for any synchro. For the correct null, connect the synchro to a voltage source and voltmeter as shown in (A) below; then turn the rotor to determine coarse zero. As the rotor is turned, one null point near the correct electrical zero will be found. To determine the fine electrical zero, connect the synchro as shown in (B) and adjust the rotor slightly until a null is established. This is the exact electrical zero.

(A) COARSE ZERO



*WHEN CDX IS USED AS CT IN S-A TWO-SPEED SYNCHRO PEDESTAL SYSTEMS.

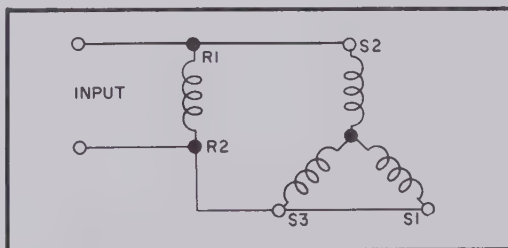
(B) FINE ZERO



*WHEN CDX IS USED AS CT IN S-A TWO-SPEED SYNCHRO PEDESTAL SYSTEMS.

To zero a synchro receiver when its shaft can rotate freely (as in a position indicator), remove all leads from the synchro and reconnect them as shown in (C). The synchro shaft will turn to the electrical zero position when rotor voltage is applied. Do not leave the synchro connected in this manner for more than two minutes, because the synchro will overheat.

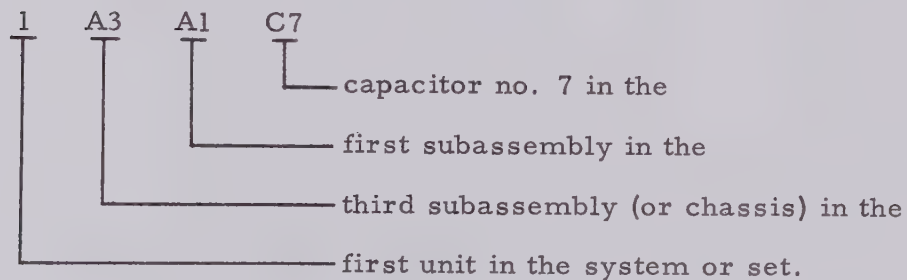
(C) RECEIVER ZERO BY ELECTRICAL LOCK



SECTION 6
PARTS LIST
MANUFACTURERS' CODE LETTERS

Code	Manufacturer
A	Aerovox
ABE	Amphenol-Borg
BA	Bendix Aviation (Montrose Div.)
BC	Barber-Coleman
BUS	Bussman
C	Con-Elco (Edcliff Instruments)
CD	Cornell-Dubilier
CH	Cutler-Hammer
CLS	Clarostat
CRL	Centralab
DI	Dialight
DM	Diehl
DP	Dale Products
GE	General Electric
HC	Hoffman Electronics
IRC	International Resistance
L	Littelfuse
MOT	Motorola
O	Ohmite
RCA	Radio Corporation of America
RE	Royal Electric
SA	Scientific-Atlanta
SC	Switchcraft
SP	Sprague Products
SY	Sylvania
T	Sarkes Tarzian
TE	Transitron Electronic
TO	Tru-Ohm
TT	Triad
USC	United States Semiconductor
UTC	United Transformer
VID	Vidar

Component-designation prefixes used in the following schematic diagram(s) and/or parts list conform to MIL-STD-16C. Individual components can be easily located in the equipment by using these prefixes. For example, a part designated as 1A3A1C7 is located as follows:



The cabling diagram shows the first two identifying prefixes of each unit, and each subassembly therein is marked with its identifying prefix.

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: MAIN CHASSIS

Component Designation	Description	Mfr.*	Mfr. Part No.
A1	Voltage-to-frequency converter, 0 to +10v input, 0- to 100-kc pulse output	VID	240A-03M
A2	Subchassis	SA	
A3	Subchassis	SA	
B1	Fan, cooling	BC	DYAB569-116
--	Blades	BC	YAB355-2
DS1	Lamp, neon glow	GE	NE-2D
F1	Fuse, 1a, slow-blow	L	313001
J1	Connector, male, 8-pin	ABE	MS3102A-18-8P
J2	Connector, male, 8-pin	ABE	MS3102A-20-7P
--	Connector, female, 8-contact	ABE	MS3106A-18-8S
--	Connector, female, 8-contact	ABE	MS3106A-20-7S
--	Connector, male, 3-pin	RE	K5135

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D

SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: MAIN CHASSIS (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
S1	Switch, toggle, SPST	CH	7501K13
S2	Switch, rotary, 5-pole, 3-position	CRL	PA2015
S3	Switch, rotary, 3-pole, 2-position	CRL	PA2015
S4	Switch, pushbutton, SPST	SC	913
S5	Switch, rotary, 2-pole, 2-position	CRL	PA2015
XDS1	Pilot-lamp assembly, red cap, with internal 56,000-ohm, 1/2w resistor	DI	137-8836-931
XF1	Fuse holder	BUS	HKP

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D

SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: SUBCHASSIS A2

Component Designation	Description	Mfr.*	Mfr. Part No.
2B1	Synchro, control transformer	BA	23CT6
2B2	Servomotor	DM	FPE-25L-107-13
2C1 thru 2C4	Capacitor, fixed, mica, 0.04 μ f $\pm$ 2%, 300v	CD	1AD3S4
2C5 2C6 2C7	Capacitor, fixed, electrolytic, 500 μ f, 50v	CD	BR500/50
2CR1 2CR3	Diode, silicon, 300v	MOT	1N3211
2CR2 2CR4	Diode, silicon, 300v	MOT	1N3211R
2CR3	See 2CR1		
2CR4	See 2CR2		
2R1	Resistor, variable, wirewound, 20,000 ohms $\pm$ 5%, 1w	IRC	CT 201-00
2R2 2R3	Resistor, variable, wirewound, 5000 ohms $\pm$ 10%, 1/2w	C	0250L-2

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D
SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: SUBCHASSIS A2 (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
2R4	Resistor, variable, composition, 50,000 ohms $\pm 10\%$, 1/2w	IRC	65LT
2R5	Resistor, variable, composition, 1000 ohms $\pm 10\%$, 1/2w	IRC	65LT
2R6 2R8	Resistor, fixed, deposited carbon, 90,000 ohms $\pm 1\%$, 1/4w	DP	DCH-1/4
2R7	Resistor, fixed, composition, 8200 ohms $\pm 10\%$, 1/2w	O	Little Devil
2R8	See 2R6		
2R9	Resistor, fixed, composition, value ($\pm 10\%$) determined at factory, 1/2w	O	Little Devil
2R10	Resistor, variable, wirewound, sine function, 20,000 ohms, $\pm 0.5\%$ conformity, servo mount	CLS	D42M
2R11 2R12 2R13	Unassigned		
2T1	Transformer, 115v/24-27-30-33-36v	TT	F-61U

* See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D

SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: SUBCHASSIS A3

Component Designation	Description	Mfr.*	Mfr. Part No.
3A1	Counter, variable reset	SA	
3A2	Counter, decade	SA	
3A3	Subassembly	SA	
3A4	Subassembly	SA	
3CR1	Diode, germanium, 200v	SY	1N91
3CR2	Diode, Zener, 11v	USC	1N1352A
3J1 3J2	Connector, printed circuit, 10- contact	ABE	143-010-01
3J3	Connector, printed circuit, 18- contact	ABE	143-018-01
3J4	Connector, printed circuit, 12- contact	ABE	143-012-01
3J5 3J6	Connector, male, 14-pin	ABE	57-40140
3P5 3P6	Connector, female, 14-contact	ABE	57-30140

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: SUBCHASSIS A3 (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
3Q1 3Q2	Transistor, germanium, PNP	RCA	2N174
3Q3	Transistor, germanium, PNP	MOT	2N441
3R1 3R2	Resistor, variable, composition, 1000 ohms $\pm 10\%$, 1/2w	IRC	65LT
3T1	Transformer, audio, 500-ohm CT pri., 16/4-ohm split secondary	UTC	A-23

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: VARIABLE RESET COUNTER 3A1

Component Designation	Description	Mfr.*	Mfr. Part No.
C1	Capacitor, fixed, silvered mica,	CD	CD15-5T15
C3	150 $\mu\mu\text{f}$, 500v		
C7			
C8			
C9			
C11			
C15			
C16			
C2	Capacitor, fixed, silvered mica,	CD	CD15-5T3
C4	300 $\mu\mu\text{f}$, 500v		
C5			
C6			
C10			
C12			
C13			
C14			
C17			
C3	See C1		
C4	See C2		
C5			
C6			
C7	See C1		
C8			
C9			
C10	See C2		
C11	See C1		
C12	See C2		
C13			
C14			
C15	See C1		
C16			
C17	See C2		

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: VARIABLE RESET COUNTER 3A1 (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
CR1 thru CR8 CR10 thru CR22	Diode, germanium, 100v	SY	1N277
CR9	Unassigned		
CR10 thru CR22	See CR1		
3A1P1	Connector, printed circuit, 10-contact	ABE	133-010-23
Q1 thru Q8	Transistor, germanium, PNP	SY	2N404A
R1 R2 R19 thru R22 R37 R38	Resistor, fixed, composition, 8200 ohms $\pm 10\%$, 1/4w	O	Little Devil

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: VARIABLE RESET COUNTER 3A1 (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
R3 R17 R23 R35	Resistor, fixed, composition, 3300 ohms $\pm 10\%$, 1/4w	O	Little Devil
R4 R18 R24 R36	Resistor, fixed, composition, 2700 ohms $\pm 10\%$, 1/4w	O	Little Devil
R5 R6 R13 R15 R25 R26 R31 R33	Resistor, fixed, composition, 68,000 ohms $\pm 10\%$, 1/4w	O	Little Devil
R7 thru R10 R27 thru R30	Resistor, fixed, composition, 10,000 ohms $\pm 10\%$, 1/4w	O	Little Devil
R11 R12	Unassigned		
R13	See R5		
R14 R16 R32 R34	Resistor, fixed, composition, 100,000 ohms $\pm 10\%$, 1/4w	O	Little Devil
R15	See R5		
R16	See R14		
R17	See R3		

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: VARIABLE RESET COUNTER 3A1 (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
R18	See R4		
R19 thru R22	See R1		
R23	See R3		
R24	See R4		
R25 R26	See R5		
R27 thru R30	See R7		
R31	See R5		
R32	See R14		
R33	See R5		
R34	See R14		
R35	See R3		
R36	See R4		
R37 R38	See R1		
R39 thru R42	Resistor, fixed, composition, 5600 ohms $\pm 10\%$, 1/4w	O	Little Devil

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: DECADE COUNTER 3A2

Component Designation	Description	Mfr.*	Mfr. Part No.
C1	Capacitor, fixed, silvered mica,	CD	CD15-5T15
C3	150 $\mu\mu\text{f}$, 500v		
C7			
C8			
C9			
C11			
C15			
C16			
C2	Capacitor, fixed, silvered mica,	CD	CD15-5T3
C4	300 $\mu\mu\text{f}$, 500v		
C5			
C6			
C10			
C12			
C13			
C14			
C3	See C1		
C4	See C2		
C5			
C6			
C7	See C1		
C8			
C9			
C10	See C2		
C11	See C1		
C12	See C2		
C13			
C14			
C15	See C1		
C16			

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: DECADE COUNTER 3A2 (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
CR1 thru CR18	Diode, germanium, 100v	TE	1N277
P4	Connector, printed circuit, 10-contact	ABE	133-010-23
Q1 thru Q8	Transistor, germanium, PNP	SY	2N404A
R1 R2 R19 thru R22 R37 R38	Resistor, fixed, composition, 8200 ohms $\pm 10\%$, 1/4w	O	Little Devil
R3 R17 R23 R35	Resistor, fixed, composition, 3300 ohms $\pm 10\%$, 1/4w	O	Little Devil
R4 R18 R24 R36	Resistor, fixed, composition, 2700 ohms $\pm 10\%$, 1/4w	O	Little Devil

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: DECADE COUNTER 3A2 (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
R5	Resistor, fixed, composition,	O	Little Devil
R6	68,000 ohms $\pm 10\%$, 1/4w		
R13			
R15			
R25			
R26			
R31			
R33			
R7	Resistor, fixed, composition,	O	Little Devil
thru	10,000 ohms $\pm 10\%$, 1/4w		
R10			
R27			
thru			
R30			
R11	Resistor, fixed, composition,	O	Little Devil
R12	5600 ohms $\pm 10\%$, 1/4w		
R39			
R13	See R5		
R14	Resistor, fixed, composition,	O	Little Devil
R16	100,000 ohms $\pm 10\%$, 1/4w		
R32			
R34			
R15	See R5		
R16	See R14		
R17	See R3		
R18	See R4		
R19	See R1		
thru			
R22			
R23	See R3		
R24	See R4		

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1 -3D

SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: DECADE COUNTER 3A2 (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
R25 R26	See R5		
R27 thru R30	See R7		
R31	See R5		
R32	See R14		
R33	See R5		
R34	See R14		
R35	See R3		
R36	See R4		
R37 R38	See R1		
R39	See R11		

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D
SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: SUBCHASSIS 3A3

Component Designation	Description	Mfr.*	Mfr. Part No.
3A3C1 3A3C2	Capacitor, fixed, electrolytic, 25 μ f, 25v	A	SRE
3A3C3 3A3C5 3A3C6	Capacitor, fixed, metallized paper, 2 μ f, 200v	A	P8292ZN14
3A3C4	Capacitor, fixed, electrolytic, 200 μ f, 6v	A	PWE6200
3A3C5 3A3C6	See 3A3C3		
3A3CR1	Diode, Zener, 5v, double anode	HC	RT-6
3A3CR2 3A3CR3 3A3CR4	Diode, Zener, 6v, single anode	HC	RS-6
3A3CR5	Diode, Zener, 5v, single anode	TE	1N2032
3A3P3	Connector, printed circuit, 18-contact	ABE	133-018-21
3A3Q1	Transistor, germanium, PNP	GE	2N404
3A3Q2	Transistor, germanium, NPN	SY	2N1605
3A3Q3 3A3Q4	Transistor, germanium, PNP	RCA	2N1183A

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: SUBCHASSIS 3A3 (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
3A3R1 3A3R11 3A3R12	Resistor, fixed, composition, 5600 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A3R2 3A3R3	Resistor, fixed, composition, 22,000 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A3R4	Resistor, fixed, composition, 10,000 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A3R5	Resistor, fixed, composition, 100 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A3R6 3A3R8	Resistor, fixed, composition, 1000 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A3R7	Resistor, fixed, composition, 1800 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A3R8	See 3A3R6		
3A3R9 3A3R10	Resistor, fixed, composition, 470 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A3R11 3A3R12	See 3A3R1		
3A3R13	Resistor, fixed, wirewound, 400 ohms $\pm 10\%$, 5w	TO	FRL5-400
3A3R14 3A3R15	Resistor, fixed, wirewound, 1 ohm $\pm 10\%$, 5w	TO	VAL5-1 (TRU-OHM)
3A3R16	Resistor, fixed, composition, 150 ohms $\pm 10\%$, 1w	O	Little Devil

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: SUBCHASSIS 3A4

Component Designation	Description	Mfr.*	Mfr. Part No.
3A4C1	Capacitor, fixed, metallized paper, 0.25 μ f, 400v	A	P8292ZN20
3A4C2	Capacitor, fixed, silvered mica, 150 μ f, 500v	CD	CD15-5T15
3A4C3	Capacitor, fixed, silvered mica, 300 μ f, 500v	CD	CD15-5T3
3A4C4 3A4C6	Capacitor, fixed, silvered mica, 100 μ f, 500v	CD	CD15-5T1
3A4C5	Capacitor, fixed, silvered mica, 200 μ f, 500v	CD	CD15-5T2
3A4C6	See 3A4C4		
3A4C7	Capacitor, fixed, Mylar, 0.0047 μ f, 400v	CD	WMF 4D47E
3A4C8	Capacitor, fixed, electrolytic, 100 μ f, 25v	CD	NLW-100-25
3A4CR1	Diode, silicon, 600v	T	1N2484 (F6)
3A4CR2 3A4CR9	Diode, germanium, 100v	SY	1N277
3A4CR3 thru 3A4CR6	Diode, silicon, 18v	HC	HB2
3A4CR7	Diode, Zener, 6v	HC	RS-6
3A4CR8	Unassigned		
3A4CR9	See 3A4CR2		

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D
SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: SUBCHASSIS 3A4 (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
3A4CR10	Diode, Zener, 18v	HC	1N1777
3A4P4	Connector, printed circuit, 12 - contact	ABE	133-012-23
3A4Q1 thru 3A4Q6	Transistor, germanium, PNP	SY	2N404A
3A4Q7	Transistor, germanium, NPN	SY	2N1605A
3A4Q8 3A4Q9	Transistor, germanium, PNP	RCA	2N1183
3A4R1	Resistor, fixed, composition, 180,000 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R2	Resistor, fixed, composition, 56,000 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R3 3A4R11	Resistor, fixed, composition, 6800 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R4	Resistor, fixed, composition, 2200 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R5 3A4R12	Resistor, fixed, composition, 1200 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R6	Resistor, fixed, composition, 8200 ohms $\pm 10\%$, 1/2w	O	Little Devil

*See "MANUFACTURERS' CODE LETTERS."

PARTS LIST

MODEL API-1-3D SPHERICAL-COORDINATE-INTEGRATOR CONVERTER UNIT

SUBASSEMBLY: SUBCHASSIS 3A4 (continued)

Component Designation	Description	Mfr.*	Mfr. Part No.
3A4R7	Resistor, fixed, composition, 39,000 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R8	Resistor, fixed, composition, determined at factory, $\pm 10\%$, 1/2w	O	Little Devil
3A4R9	Resistor, fixed, composition, 820 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R10	Resistor, fixed, composition, 10,000 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R11	See 3A4R3		
3A4R12	See 3A4R5		
3A4R13	Resistor, fixed, composition, 680 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R14 3A4R22	Resistor, fixed, composition, 1000 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R15	Resistor, fixed, composition, 1000 ohms $\pm 10\%$, 1w	O	Little Devil
3A4R16	Resistor, fixed, composition, 2700 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R17	Resistor, fixed, composition, 470 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R18	Resistor, fixed, composition, 1800 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R19	Resistor, fixed, composition, 3300 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R20	Resistor, fixed, composition, 390 ohms $\pm 10\%$, 2w	O	Little Devil
3A4R21	Resistor, fixed, composition, 560 ohms $\pm 10\%$, 1/2w	O	Little Devil
3A4R22	See 3A4R14		

*See "MANUFACTURERS' CODE LETTERS."

CONVERSION OF VOLTAGE AND POWER RATIOS TO DECIBELS

The basic chart below indicates the number of decibels (db) corresponding to the listed ratios of voltage or power over the range of -20 to +20 db. For voltage or power ratios greater than those included in the chart, the ratio can be broken down into a product of two numbers, the value in db for each found separately, and the two results added. Example: To convert a power ratio of

2,000:1 to db, express 2,000 as 2×10^3 ; the number of db corresponding to a power ratio of 2 is very nearly 3, and the number of db for a power ratio of 10^3 is 30. Therefore, the power ratio of 2,000:1 is approximately 30 db + 3 db = 33 db. In the lower right-hand corner of the chart db values for voltage and power ratios of integral powers of 10 are given.

Voltage Ratio	Power Ratio	-db+	Voltage Ratio	Power Ratio	Voltage Ratio	Power Ratio	-db+	Voltage Ratio	Power Ratio	Voltage Ratio	Power Ratio	-db+	Voltage Ratio	Power Ratio
1.000	1.000	0	1.000	1.000	.447	.200	7.0	2.239	5.012	.200	.0398	14.0	5.012	25.12
.989	.977	.1	1.012	1.023	.442	.195	7.1	2.265	5.129	.197	.0389	14.1	5.070	25.70
.977	.955	.2	1.023	1.047	.437	.191	7.2	2.291	5.248	.195	.0380	14.2	5.129	26.30
.966	.933	.3	1.035	1.072	.432	.186	7.3	2.317	5.370	.193	.0372	14.3	5.188	26.92
.955	.912	.4	1.047	1.096	.427	.182	7.4	2.344	5.495	.191	.0363	14.4	5.248	27.54
.944	.891	.5	1.059	1.122	.422	.178	7.5	2.371	5.623	.188	.0355	14.5	5.309	28.18
.933	.871	.6	1.072	1.148	.417	.174	7.6	2.399	5.754	.186	.0347	14.6	5.370	28.84
.923	.851	.7	1.084	1.175	.412	.170	7.7	2.427	5.888	.184	.0339	14.7	5.433	29.51
.912	.832	.8	1.096	1.202	.407	.166	7.8	2.455	6.026	.182	.0331	14.8	5.495	30.20
.902	.813	.9	1.109	1.230	.403	.162	7.9	2.483	6.166	.180	.0324	14.9	5.559	30.90
.891	.794	1.0	1.122	1.259	.398	.159	8.0	2.512	6.310	.178	.0316	15.0	5.623	31.62
.881	.776	1.1	1.135	1.288	.394	.155	8.1	2.541	6.457	.176	.0309	15.1	5.689	32.36
.871	.759	1.2	1.148	1.318	.389	.151	8.2	2.570	6.607	.174	.0302	15.2	5.754	33.11
.861	.741	1.3	1.161	1.349	.385	.148	8.3	2.600	6.761	.172	.0295	15.3	5.821	33.87
.851	.724	1.4	1.175	1.380	.380	.145	8.4	2.630	6.918	.170	.0288	15.4	5.888	34.68
.841	.708	1.5	1.189	1.413	.376	.141	8.5	2.661	7.079	.168	.0282	15.5	5.957	35.48
.832	.692	1.6	1.202	1.445	.372	.138	8.6	2.692	7.244	.166	.0275	15.6	6.026	36.31
.822	.676	1.7	1.216	1.479	.367	.135	8.7	2.723	7.413	.164	.0269	15.7	6.095	37.15
.813	.661	1.8	1.230	1.514	.363	.132	8.8	2.754	7.586	.162	.0263	15.8	6.166	38.02
.804	.646	1.9	1.245	1.549	.359	.129	8.9	2.786	7.762	.160	.0257	15.9	6.237	38.90
.794	.631	2.0	1.259	1.585	.355	.126	9.0	2.818	7.943	.159	.0251	16.0	6.310	39.81
.785	.617	2.1	1.274	1.622	.351	.123	9.1	2.851	8.128	.157	.0246	16.1	6.383	40.74
.776	.603	2.2	1.288	1.660	.347	.120	9.2	2.884	8.318	.155	.0240	16.2	6.457	41.69
.767	.589	2.3	1.303	1.698	.343	.118	9.3	2.917	8.511	.153	.0234	16.3	6.531	42.66
.759	.575	2.4	1.318	1.738	.339	.115	9.4	2.951	8.710	.151	.0229	16.4	6.607	43.65
.750	.562	2.5	1.334	1.778	.335	.112	9.5	2.985	8.913	.150	.0224	16.5	6.683	44.67
.741	.550	2.6	1.349	1.820	.331	.110	9.6	3.020	9.120	.148	.0219	16.6	6.761	45.71
.733	.537	2.7	1.365	1.862	.327	.107	9.7	3.055	9.333	.146	.0214	16.7	6.839	46.77
.724	.525	2.8	1.380	1.905	.324	.105	9.8	3.090	9.550	.145	.0209	16.8	6.918	47.86
.716	.513	2.9	1.396	1.950	.320	.102	9.9	3.126	9.772	.143	.0204	16.9	6.998	48.98
.708	.501	3.0	1.413	1.995	.316	.100	10.0	3.162	10.000	.141	.0200	17.0	7.079	50.12
.700	.490	3.1	1.429	2.042	.313	.0977	10.1	3.199	10.23	.140	.0195	17.1	7.161	51.29
.692	.479	3.2	1.445	2.089	.309	.0955	10.2	3.236	10.47	.138	.0191	17.2	7.244	52.48
.684	.468	3.3	1.462	2.138	.306	.0933	10.3	3.273	10.72	.137	.0186	17.3	7.328	53.70
.676	.457	3.4	1.479	2.188	.302	.0912	10.4	3.311	10.96	.135	.0182	17.4	7.413	54.95
.668	.447	3.5	1.496	2.239	.299	.0891	10.5	3.350	11.22	.133	.0178	17.5	7.499	56.23
.661	.437	3.6	1.514	2.291	.295	.0871	10.6	3.388	11.48	.132	.0174	17.6	7.586	57.54
.653	.427	3.7	1.531	2.344	.292	.0851	10.7	3.428	11.75	.130	.0170	17.7	7.674	58.88
.646	.417	3.8	1.549	2.399	.288	.0832	10.8	3.467	12.02	.129	.0166	17.8	7.762	60.26
.638	.407	3.9	1.567	2.455	.285	.0813	10.9	3.508	12.30	.127	.0162	17.9	7.852	61.66
.631	.398	4.0	1.585	2.512	.282	.0794	11.0	3.548	12.59	.126	.0159	18.0	7.943	63.10
.624	.389	4.1	1.603	2.570	.279	.0776	11.1	3.589	12.88	.125	.0155	18.1	8.035	64.57
.617	.380	4.2	1.622	2.630	.275	.0759	11.2	3.631	13.18	.123	.0151	18.2	8.128	66.07
.610	.372	4.3	1.641	2.692	.272	.0741	11.3	3.673	13.49	.122	.0148	18.3	8.222	67.61
.603	.363	4.4	1.660	2.754	.269	.0724	11.4	3.715	13.80	.120	.0143	18.4	8.318	69.18
.596	.355	4.5	1.679	2.818	.266	.0708	11.5	3.758	14.13	.119	.0141	18.5	8.414	70.79
.589	.347	4.6	1.698	2.884	.263	.0692	11.6	3.802	14.45	.118	.0138	18.6	8.511	72.44
.582	.339	4.7	1.718	2.951	.260	.0676	11.7	3.846	14.79	.116	.0135	18.7	8.610	74.13
.575	.331	4.8	1.738	3.020	.257	.0661	11.8	3.890	15.14	.115	.0132	18.8	8.710	75.86
.569	.324	4.9	1.758	3.090	.254	.0646	11.9	3.936	15.49	.114	.0129	18.9	8.811	77.62
.562	.316	5.0	1.778	3.162	.251	.0631	12.0	3.981	15.85	.112	.0126	19.0	8.913	79.43
.556	.309	5.1	1.799	3.236	.248	.0617	12.1	4.027	16.22	.111	.0123	19.1	9.016	81.28
.550	.302	5.2	1.820	3.311	.246	.0603	12.2	4.074	16.60	.110	.0120	19.2	9.120	83.18
.543	.295	5.3	1.841	3.388	.243	.0589	12.3	4.121	16.98	.108	.0118	19.3	9.226	85.11
.537	.288	5.4	1.862	3.467	.240	.0575	12.4	4.169	17.38	.107	.0115	19.4	9.333	87.10
.531	.282	5.5	1.884	3.548	.237	.0562	12.5	4.217	17.78	.106	.0112	19.5	9.441	89.13
.525	.275	5.6	1.905	3.631	.234	.0550	12.6	4.266	18.20	.105	.0110	19.6	9.550	91.20
.519	.269	5.7	1.928	3.715	.232	.0537	12.7	4.315	18.62	.104	.0107	19.7	9.661	93.33
.513	.263	5.8	1.950	3.802	.229	.0525	12.8	4.365	19.05	.102	.0105	19.8	9.772	95.50
.507	.257	5.9	1.972	3.890	.227	.0513	12.9	4.416	19.50	.101	.0102	19.9	9.886	97.72
.501	.251	6.0	1.995	3.981	.224	.0501	13.0	4.467	19.95	.100	.0100	20.0	10.000	100.00
.496	.246	6.1	2.018	4.074	.221	.0490	13.1	4.519	20.42		10^{-3}	30	10^3	
.490	.240	6.2	2.042	4.169	.219	.0479	13.2	4.571	20.89		10^{-4}	40	10^4	
.484	.234	6.3	2.065	4.266	.216	.0468	13.3	4.624	21.38	10^{-2}				
.479	.229	6.4	2.089	4.365	.214	.0457	13.4	4.677	21.88					
.473	.224	6.5	2.113	4.467	.211	.0447	13.5	4.732	22.39	10^{-3}	10^{-5}	50	10^5	10^3
.468	.219	6.6	2.138	4.571	.209	.0437	13.6	4.786	22.91		10^{-6}	60	10^6	10^5
.462	.214	6.7	2.163	4.677	.207	.0427	13.7	4.842	23.44	10^{-4}	10^{-7}	70	10^7	10^7
.457	.209	6.8	2.188	4.786	.204	.0417	13.8	4.898	23.99		10^{-8}	80	10^8	10^8
.452	.204	6.9	2.213	4.898	.202	.0407	13.9	4.955	24.55		10^{-9}	90	10^9	10^9
										10^{-5}	10^{-10}	100	10^5	10^{10}
											10^{-11}	110	10^{11}	10^{11}
										10^{-6}	10^{-12}	120	10^6	10^{12}

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